

pressure cylinders, and this involves the use of a junk ring as the restraining member is, of course, not split. There are many varieties of piston rings manufactured by private firms or specialists, and these are sometimes specified by users because of the special advantages that are claimed for them. One of the best known for high-speed engine work is the "Rowan", of which details are given.

When junk rings are used, special precautions must be taken to prevent the possibility of the set screws slacking back and coming adrift. In all cases tapped holes should be provided in the piston boss, into which eye bolts can be screwed for the purpose of withdrawing the piston from the cylinder.

Piston-rod and Crosshead, Slippers and Guides.—The usual method of fixing the piston to the rod is by means of a nut screwed on to the end of the latter. The nut is of the castle type, grooves being milled across the face to take a split pin. The part of the rod inside the piston boss consists of a parallel part having the same diameter as the top of the thread, and a taper part. It is bad practice to make the taper too small. The rod is then difficult to extract from the piston, and in the event of water getting into the cylinder the rod may burst the piston by wedging action. The taper is usually made 1 in 4 on the diameter, and this is satisfactory for all types of engine. The tensile stress allowed upon the section at the bottom of the thread is 5000 lb. per square inch for small engines, and 7000 lb. for large engines, the load being taken at full boiler pressure on the high-pressure piston. Some makers use a high-tensile steel for piston-rods, and the stress may then be somewhat greater. It should not be forgotten that such parts as piston-rods and crosshead and connecting-rod bolts are nicked by the screwed part and have an inherent tendency to failure there. The stress on the body of the rod is usually very low, as the diameter is much greater than the screwed part, owing to the taper of the part in the piston and the shoulder left upon the rod. In addition, there is an allowance of $\frac{1}{8}$ to $\frac{1}{4}$ in. for re-

turning. High-speed engine piston-rods are short compared with their diameter, and this condition, combined with the low stress, makes failure by crippling unlikely.

The combination of crosshead, guide, and connecting-rod top end have given rise to many variations in design with all kinds of screw, wedge, and cotter adjustments and fastenings, but generally only two types are now used, both being taken almost unchanged from marine engine practice. This may be accounted for by the fact that the high-speed engine was to a great extent developed by firms who had had previous experience in naval and marine work, where the types referred to have been found quite reliable and satisfactory.

In one type the crosshead pin is fixed in the jaws of the connecting-rod and partakes of its angular movements, the bearing remaining fixed and forming part of the crosshead. In the other type the bearings are carried by the jaws of the connecting-rod, the gudgeons being solid with the cross-head body. Both types necessitate a forked connecting-rod end.